Identification of Wastewater CH4 Emission Sources with Computer Vision and Sentinel-2 Observations

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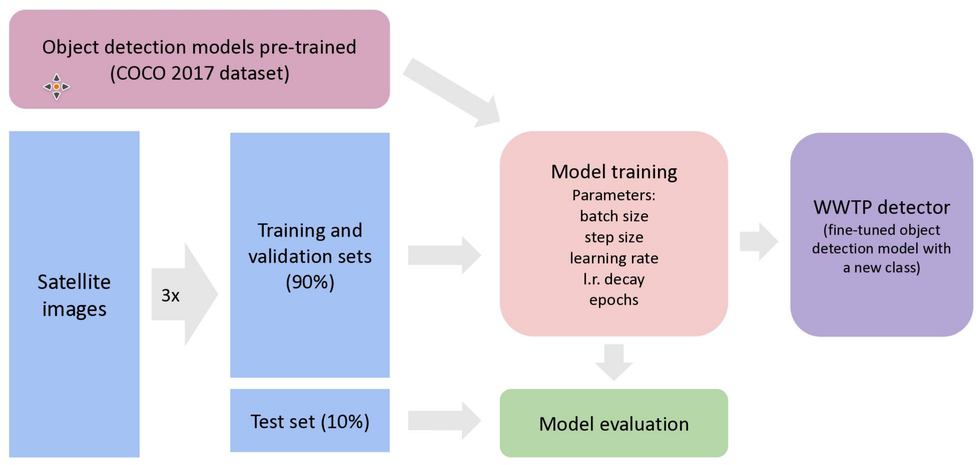
Introduction

- CH4 is a greenhouse gas not as prevalent in the atmosphere as CO2 but far more potent [1]
- According to the Emissions Database for Global Atmospheric Research (EDGAR), a global emission inventory, the wastewater disposal sector accounted for 5 to 20% of the CH4 emitted in 2012 [2]
- Current emission inventories lack spatial representativeness due to the usage of the population density to allocate emissions from wastewater treatment plants (WWTP)
- We developed a Deep Learning-based methodology for the identification and localization of Spanish CH4 emission sources, with a focus on wastewater treatment plants (WWTP) using European Space Agency images from the Sentinel-2 mission

Implementation

- The Urban Waste Water Treatment database (UWWT-DB) is used for extracting the location of the WWTPs in Spain [3]
- We implement a WWTP detection model using the Tensorflow Object Detection API [4], fine-tuning two state-of-the-art computer vision models: Faster R-CNN [5] and EfficientDet [6]
- Red, Green and Blue Sentinel-2 bands at 10 m resolution are cropped for extracting images of Spanish WWTPs from the UWWT-DB
- Samples from the same plants are extracted from Google Earth at 1 m resolution
- Bounding boxes are created manually for 500 WWTPs on both Sentinel-2 and Google Earth images

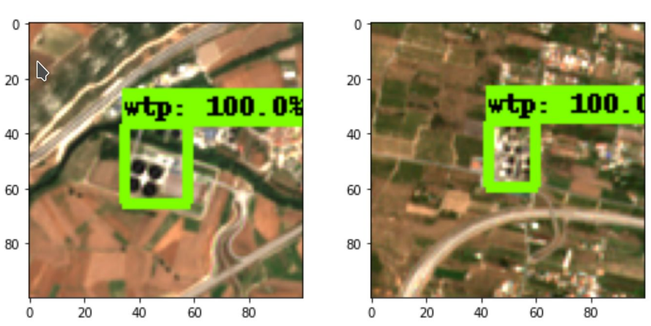
WWTP and its bounding box



Workflow for implementing the WWTP detection model

Results

- We evaluate the models in terms of the mean Average Precision (mAP) for an Intersection Over Union larger than 0.5
- The mAP for the two models and the two sets of training images is given in the table below
- The left panel shows examples of the model predictions on Sentinel-2 data



Examples of WWTP detected on Sentinel-2 images

	mAP (*Google Earth data*)	mAP (*Sentinel-2 data*)
Faster R-CNN	0,79	0,62
EfficientDet	0,89	0,70

Table with the comparison of two different object detection models and datasets at 1 m and 10 m resolutions

What's next?

- We obtained promising results in localizing wastewater plants even at the 10 m resolution of Sentinel-2 images
- The training dataset could be expanded with more examples (from the UWWT-DB)
- A simple analysis shows a relationship between the plant size and its water treatment capacity (Pearson correlation coefficient: 0,64)
- In the future we will couple a regression model for predicting each plant's capacity and use it as proxy for CH4 emissions to improve the existing methodologies for spatial distribution of emissions

References

[1] IPCC report, 2019
[2] Janssens-Maenhout et al., 2019, "EDGAR v4.3.2 Global Atlas of the three major Greenhouse Gas Emissions for the period 1970–2012"
[3] Urban Waste Water Treatment database: https://www.eea.europa.eu/data-and-maps/data/waterbase-uwwtd-urban-waste-water-treatment-directive-6
[4] Tensorflow Object Detection API: https://github.com/tensorflow/models/tree/master/research/object_detection
[5] Ren et al. 2015, "EfficientDet: Scalable and Efficient Object Detection"
[6] Tan et al. 2019, "Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Networks"

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